

Dear Referee,

We would like to thank you for reviewing our manuscript and giving valuable feedbacks. Please find our responses to your comments in blue text and revised manuscript in red text below.

Best regards,

Yanan Wang and co-authors

The authors have added the notation $p(r)$ to refer to the perimeter density (per unit ice area) for floes of radius r . The notation P refers to the integral of $p(r)$ over all values of r . This distinction is certainly helpful for understanding the analysis. The most remarkable result from this work, in my opinion, is the complete lack of agreement between data and models, and between the models themselves (Figures 2 and 3).

Below are my comments on the latest revision of the manuscript. Page and line numbers refer to the "clean" file
tc-2022-130-manuscript-version4.pdf

Page 3, line 68. "we derived a new FSD dataset from 1-m resolution MEDEA imagery" Note that Denton and Timmermans (2022) did the same thing. Please acknowledge their work.

Denton and Timmermans (2022), Characterizing the sea-ice floe size distribution in the Canada Basin from high-resolution optical satellite imagery, *The Cryosphere*, 16, 1563–1578,

<https://doi.org/10.5194/tc-16-1563-2022>

We have added an introduction of recent observations and cited this paper. Please see Lines 57–61 on Page 2 in the updated manuscript.

To enhance the understanding of the FSD evolution in various seasons and regions in the Arctic, a wide range of observations from aerial vehicles (e.g., Perovich and Jones, 2014; Toyota et al., 2016), optical satellites, e.g., Landsat (e.g., Rothrock and Thorndike, 1984; Gherardi and Lagomarsino, 2015; Wang et al., 2016), MEDEA (e.g., Denton and Timmermans, 2021; Hwang and Wang, 2022), MODIS (Toyota et al., 2016; Stern et al., 2018a), and Synthetic Aperture Radar (SAR), e.g., TerraSAR-X (Hwang et al., 2017b; Stern et al., 2018a), have been used to derive floe sizes.

Page 7, lines 190-191. When introducing $p(r)$ just before equation (1), it would be helpful to state that $p(r)$ is proportional to $r \cdot n(r)$.

Thanks. We have revised in the revised manuscript (Lines 195-200 on Page 7).

For the evaluation of FSD models, we consider the perimeter density distribution, $p(r)dr$ (units: km km^{-2}), which is proportional to $r \cdot n(r)dr$. Perimeter density distribution defined here as the perimeter of floes per unit ice area with radius between r and $r + dr$. The integral of $p(r)$ between r_{\min} and r_{\max} in radius is defined as total perimeter density,

$$P = \int_{r_{\min}}^{r_{\max}} p(r)dr, \quad (1)$$

which is the perimeter per unit ice area of floes between r_{\min} and r_{\max} .

Page 7, lines 195-196. "P is often used as a way to capture useful information about the FSD using a singular value"

As stated in my first and second reviews, P does not convey anything about the FSD. Any number of different FSDs can give rise to the same P. It is not possible to go backwards from P and say anything about the FSD from which it was calculated. P is a legitimate metric to use for comparing models and observations, but it does not "capture useful information about the FSD".

We have revised these sentences as follows. Please see Lines 201–203 on Page 7 in the revised manuscript.

The concept of a perimeter density to characterize the overall floe size has been used in several previous observational studies (e.g., Perovich, 2002; Arntsen et al., 2015),

Page 7, lines 199-201. "In this study, P (units: km km^{-2}) is used as it captures the most useful information about FSD shape... Whilst information about FSD shape is lost when calculating P.."

Again, P does not capture anything about FSD shape. Furthermore, it seems odd to claim that P captures the most useful information about FSD shape and then admit in the next sentence that information about FSD shape is lost when calculating P.

We have revised these sentences as follows. Please see Lines 204-205 on Page 7 in the revised manuscript.

In this study, P (units: km km^{-2}) is used to present comparisons between observations and models.

Page 8, line 237. "regional difference (Figs. 2c and 2d)."

I believe this should be Figs. 2b and 2d (not 2c).

We have revised in the revised manuscript (Line 241 on Page 8).

WIPoFSD (Chukchi Sea: $120.93 \pm 1.66 \text{ km km}^{-2}$, Fram Strait: $138.99 \pm 12.98 \text{ km km}^{-2}$) and CPOM-FSD (Chukchi Sea: $59.55 \pm 19.13 \text{ km km}^{-2}$, Fram Strait: $61.19 \pm 29.95 \text{ km km}^{-2}$) also show a general overestimation of P to the observations and the opposite regional difference (Figs. 2b and 2d).

Page 9, line 266. "In Sect. 3.1"

I believe this should be 4.1

We have revised in the revised manuscript (Lines 270 on Page 9).

In Sect. 4.1, the three models all show larger value of $p(r)$ for small floes ($r < 10\text{--}30 \text{ m}$) than the observations (Figs. 2e–2k).

Page 9, line 266. "than the observations (Figs. 3e-k)."

I believe this should be Figs. 2e-k (not 3).

We have revised in the revised manuscript (Lines 270 on Page 9).

In Sect. 4.1, the three models all show larger value of $p(r)$ for small floes ($r < 10\text{--}30 \text{ m}$) than the observations (Figs. 2e–2k).

Page 9, line 267. "This large value of modelled $p(r)$ for small floes may be attributed to the limited image resolution in retrieving small floes." This makes no sense, because the modelled $p(r)$ has nothing to do with the image resolution. The models and the observations are independent. The sentence should be phrased something like this: "The limited image resolution may hinder the retrieval of small floes. To test this..."

We have revised in the revised manuscript (Lines 271 on Page 9).

The limited image resolution may hinder the retrieval of small floes. To test this, we investigate $p(r)$ derived from MEDEA...

Pages 9-10, lines 276-278. "the floe welding rate is set to be proportional to the square of SIC in the two prognostic models, FSDv2-WAVE and CPOM-FSD based on observations that the welding rate correlates with SIC (Roach et al., 2018b)."

Correlation implies a linear relationship. If "the welding rate correlates with SIC" then it's proportional to SIC, not SIC². If Roach et al (2018b) found that the welding rate is proportional to SIC² then just write "the floe welding rate is set to be proportional to the square of SIC in the two prognostic models, FSDv2-WAVE and CPOM-FSD, based on the work of Roach et al (2018b)."

We have revised in the revised manuscript (Lines 279-281 on Page 9).

For example, the floe welding rate is set to be proportional to the square of SIC in the two prognostic models, FSDv2-WAVE and CPOM-FSD based on the work of Roach et al. (2018b).

Page 11, lines 333-334. "The P values from the northern regions are considerably smaller than the values from the southern regions for the two models"

I'm looking at Table 3. I see that the above statement is true for FSDv2-WAVE in the CS region, and for CPOM-FSD in the FS region, but it is not true for FSDv2-WAVE in the FS region nor for CPOM-FSD in the CS region.

We have revised in the revised manuscript (Lines 336-337 on Page 11).

The P values from the northern regions are smaller than the values from the southern regions for the two models (Fig. 7).

Page 11, line 336. "comparable to the observation values (Fig. 7a and Table 3)." Table 3 says nothing about observation values. Just write "(Fig. 7a)."

We have revised in the revised manuscript (Line 339 on Page 11).

In the Chukchi Sea region, the SIC values from the northern region are clustered between 90% and 100%, and the P values for both models are comparable to the observation values (Fig. 7a).

Page 27, line 691, second line of Figure 6 caption. Change "FSD" to "P"

We have revised Figure 6 caption.

*Figure 6: Monthly changes of **P** simulated by the two prognostic models over the period May to July during 2000–2014. (a) Change of **P** arising from lateral melt for FSDv2-WAVE in the Chukchi Sea. (b) is same as (a) but for wave induced **P** change. (c) and (d) are same as (a) and (b) but in the Fram Strait. (e)–(h) is same as (a)–(d) but for CPOM-FSD. The blue and red box in (a) and (c) show the northern and southern region of the two study regions. Black dots indicate the location of observations in the study regions.*

Supplementary Materials

Page 2, line 53. "Based on Eq. 12 in the main text"
There is no equation 12 in the main text.

Thanks. It should be Eq. 2 in the main text. We have revised in the updated supplementary materials (Line 53 on Page 2).

Based on Eq. 2 in the main text